

A Reconfigurable Magnonic-Spintronic Device Based on Domain Wall for Information Processing

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To address the energy crisis in computation, we investigate hybrid magnonic-spintronics device for in-memory computing. Using mumax3 simulations, we study an in-plane magnetized system composed of a soft ferromagnetic stripe (e.g., Ni or Py), capable of stabilizing domain walls (DWs) via notches or curvature, when placed above a YIG film (Fig. 1). Initially,

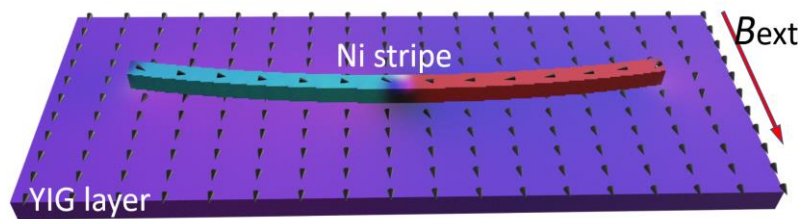


Figure 1. A YIG layer with an Ni stripe placed above it, under an external magnetic field (B_{ext}).

we observe that the stray field from the DW locally modifies the YIG layer magnetization, inducing a phase shift in propagating spin waves (SWs). This phase shift can be controlled by repositioning the DW along the stripe using pulse-currents., enabling a reconfigurability. This device can overcome limitations of the neural network present in Ref. [1], by offering easily implemented and energetically effective re-programmability necessary for network teaching.

Another finding is based on stabilizing DWs in low-gradient energy minimum positions along the stripe through curvature or magnetization saturation gradients. We demonstrate that dynamic stray fields generated by SW propagating in the YIG layer with wavevector parallel to the stripe length and frequencies corresponded to resonance in ferromagnetic stripe can displace the DW when waves pass under the DW [2]. In low energy-gradient scenarios, the DW returns to its initial position post-SW excitation, functioning effectively as a flip-flop memory element.

These findings highlight the potential of the proposed hybrid magnonic-spintronics devices as robust platform for neuromorphic computing. Future research will focus on optimizing stripe geometry, material selection, and enhancing SW-DW coupling to further improve device performance.

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References

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